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STANFORD UNIV CALIF DEPT OF APPLIED PHYSICS
PROTON TRANSFERS IN HYDROGEN-BONDED NUCLEIC ACIDS.(U)
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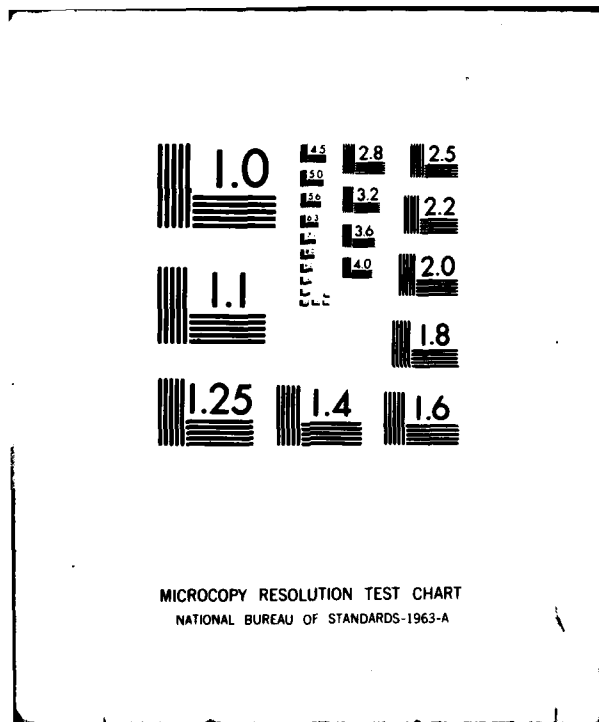
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STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

DEPARTMENT OF APPLIED PHYSICS

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To: Office of Naval Research
From: M. Weissbluth
Professor of Applied Physics

Re: O.N.R. N00014-78-C-0317 Final Report
Proton Transfers in Hydrogen-Bonded Nucleic Acids.

I. INTRODUCTION

ONR Contract No. N00014-78-C-0317 entitled "Proton Transfer in Hydrogen-Bonded Nucleic Acids" was funded for a total estimated cost of \$29,980 beginning April 1, 1978 for a period of one year. Shortly after initiation of this contract I was asked by ONR to serve as a Senior Liaison Scientist at ONR, Tokyo. I left for Japan on August 3, 1978 and returned to Stanford University on September 1, 1979. In view of my absence from Stanford for most of the contract period, I requested and was granted a no-funds extension of six months. Approval was also granted for Prof. R.L. Byer to act as co-principal investigator. Mr. Eric Gustafson, a graduate student in the Department of Applied Physics, was supported from contract funds.

II. U.S. - JAPAN COLLABORATION

During my stay in Japan I became acquainted with Professor Yoshimasa Kyogoku at the Institute for Protein Research, Osaka University. Prof. Kyogoku and his research group found that selective hydrogen bonds between nucleic acid bases are formed even in non-aqueous solvents and that base pair formation is not a specific characteristic of polynucleotides but rather of the purine and pyrimidine bases. By using infrared and nuclear magnetic resonance spectroscopy the structure distribution and thermodynamic function of the base pairs have been determined on the model systems. Recently it was found by use of the saturation transfer method in NMR that the amino and imino protons in the A-T, G-C base pair exchange with each other at a rate of

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10^{-12} sec⁻¹. The frequency of the proton transfer seems to relate to the ease of forming the tautomeric form. The proposed mechanism suggests that proton rearrangements by tunneling occur as an initial step. It is interesting that the phenomenon is most remarkable between adenine (A) and 5-bromouracil, a known mutagenic agent.

Prof. Kyogoku and I discussed the possibility of a collaborative effort between his group at Osaka University and our group at Stanford. This has culminated in an agreement to seek support under the United States Cooperative Science Program, administered in Japan by the Japanese Society for the Promotion of Science (JSPS) and in the U.S. by the Division of International Programs at NSF. Proposals to these agencies are now in preparation.

III. OPTICAL SYSTEM

The work at Stanford consisted mainly in the design and improvement of the optical and spectroscopic system. A block diagram is shown in the accompanying figure.

The heart of the system is the optical parametric oscillator (OPO) which employs an angle-tuned LiNbO_3 crystal pumped by a Nd:YAG laser. Improvements in fabrication techniques have resulted in LiNbO_3 crystals up to 20 mm in diameter and 6 cm in length. A troublesome absorption at 2.85 μm due to OH^- and which, in some cases, prevented oscillation at that wavelength has been virtually eliminated, resulting in much-improved optical quality. The LiNbO_3 parametric oscillator operates over a range of 1.4 - 4 μm as a singly resonant oscillator with the 1.4 - 2.1 μm signal wave resonated within a 13 cm long optical cavity formed by a grating and 50% reflecting output coupler. The grating provides linewidth control to less than 2 cm^{-1} . The overall tuning range is 1.4 - 4.4 μm with an output of 10 mJ in a 10 nsec pulse and a bandwidth of 4 - 6 cm^{-1} with a grating and 0.1 cm^{-1} with an etalon.

The optical parametric oscillator is used for irradiating the sample in order to put the system in an excited state and thereby enhance the tunneling probability. The detection of a tautomeric transition is implemented spectroscopically by the onset of an OH vibration frequency or the reduction of an NH_2 characteristic vibration frequency. Either way events are monitored by

infrared radiations. The latter is produced as a difference frequency between the output of a single mode dye laser operating at two wavelengths, 488 and 514.5 nm. This provides 200 μ W of CW power in the two ranges 2.29 - 3.80 μ m and 3.02 - 6.30 μ m.

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